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Suggestions on the classification of Metaphyta.

CONWAY MACMILLAN.

The sciences of botany and zoölogy are not yet sufficiently advanced, it may be, for the proposal of that system of classification which, at once comprehensive and natural, shall bind together all our ontogenetic and phylogenetic discoveries and generalizations into a harmonious and enduring structure. The season of patient toil in the acquisition of new facts in the departments of comparative morphology and embryology is not yet past; and to both the zoölogist and the botanist there is still a vast terra-incognita presenting its untried paths for the work of discovery and cartography. To indicate what seems to be a possibly fruitful line of investigation—or rather to suggest the continued investigation of an already indicated and partially explored region, from a somewhat different point of view than the ordinary one—is the object of this paper.

The bald statement that there exists a great group of living creatures with which students of biology have long been familiar, but of which there is as yet no classification, no *Systema*, no Tournefort or Linnaeus, and no compendium or monograph of any sort, borders closely on the sensational. From a certain point of view this is, however, a fair statement and one that can be defended. The groups to which reference is made have been studied since the time of Camerarius and properly understood since the days of Hofmeister. Their presence as organisms is nevertheless owing to the persistence of ancient habits of thought, largely overlooked by the students of to-day. The accepted classification of the plant kingdom into Protophyta and Metaphyta buries every vestige of the group, and it is only by modifying that classification that the lost tribes may be made to emerge from their obscurity. In the briefest manner let us examine the ascertained facts of progress which are considered of importance in determining the rank of successive series of plants and animals. First and lowest in the scale of differentiation are those organisms which can not be safely grouped either with the plants or with the animals. These are the Protista of Hæckel, the third kingdom. From them as a substratum the two phyla of plants and animals arise. In each branch of the primitive trunk the lower series of organisms are devoid of sex, purely vegetative even in their reproductive functions. These are

the Protophyta and the Protozoa, or if one should apply names to indicate the physiological character upon which the groups are founded, the Agamophyta or sexless plants, and the Agamozoa or sexless animals. With such transitional forms as *Ulothrix* and some of the ciliated Infusoria the two higher groups of organisms are introduced and we may distinguish the sexual plants, Gamophyta, from the sexual animals, Gamozoa. This latter branch is almost equivalent to the Metazoa, but the Gamophyta as here limited constitute but a small portion of the organisms which are included as Metaphyta. It is precisely here that the great hiatus between our classification of plants and animals is to be discerned. To appreciate properly the true condition of things is perhaps more easy if we divide the Metazoa and Metaphyta, respectively, into two co-ordinate groups. This is a division of organisms, not of species, and can be performed, I think, without violence to right thinking. There may be distinguished, then, in the plant phylum the Sporophyta and the Gamophyta, and in the animal phylum the Sporozoa and Gamozoa. A sporophytic or sporozoic organism might be defined briefly as one that develops primarily from a segmentation-cell (fertilized egg, parthenogetic egg or vegetatively apogamous cell) and normally forms in turn perfect reproductive cells or *spores*. In the plant phylum this group includes a most diverse and numerous series of organisms, from the four-zoospore-plant of *Cedogonium* to the moss-capsule, the ferns, club-mosses, pines, cycads, and all the herbs, shrubs and trees with which we are familiar. In the animal phylum, however, the Sporozoa would include only a very few and relatively insignificant organisms, chiefly among the Cœlenterata, and doubtfully extending among the Tunicata; that depending upon whether the views of Brooks or of his critics are to be accepted concerning the homologies of the salpa-chain.

With the division of the two branches, Metaphyta and Metazoa, it becomes apparent why the coördination of plants and animals under any of the systems is so unproductive of the most valuable systematic or philosophical results. We do not compare, habitually, the Sporophyta with the Sporozoa, but with the Gamozoa, thus missing the chance of determining the true parallelisms and homologies, if any exist. That sporophytic structures may not be compared (except physiologically) with gamophytic has already been shown by

Bower,¹ but it does not seem to be out of place to insist here that such structures and organisms are even less aptly compared with the Gamozoa.

It will be recognized as of high importance to discriminate in the two divergent phyla of plants and animals the truly double and parallel composition of each of the upper series. And, since the structural development in the two phyla varies reciprocally, it is not possible to compare them without clearly perceiving the double nature of each. For in the Metaphyta the sexual series has undergone progressive structural degeneration from the mosses to the highest of the Siphonogama, while in the Metazoa the sexual series manifests increasing complexity from the lowest Cœlenterata to the Primates. On the other hand, in the plant phylum, sporophytic organisms from the Cœdogoniæ to the highest Metachlamydeæ show a constantly increasing structural differentiation; but in the animal phylum, sporozoan organisms are developed only low down in the scale and are discontinued long before the higher classes are reached. I have already indicated elsewhere what may be the reason for this remarkable difference between the two kingdoms², and it will suffice to suggest that the relatively great immobility of gamete-producing, that is sexual, plants is the primary cause of their defeat in the struggle for food, sunlight and organization with the more capable sporophytes. This supremacy of the sporophytes is so complete that all the higher gamophytic plants have been forced into a most abject condition of parasitism upon the sporophytic structures of their own species.

The great mass of the species grouped in the Metaphyta are, therefore, persistently and strongly dimorphic, and it is this dimorphism which distinguishes the plant from the animal phylum. The essential diagnostic character of the Metaphyta might be described, indeed, as sharply defined specific dimorphism. While the higher animals may, for each species, be separated into two groups of organisms differing only in sex, the higher plants may, for each species, be divided into perhaps four groups or organisms, viz., the pollen-bearing, the pistil-bearing, the male (pollen-tube) and the female (embryo-sac contents). This conception of the plant

¹Bower: Antithetic and Homologous Alternation; *Ann. of Bot.* IV, 347-370, 1890.

²MacMillan: *Amer. Nat.* XXV, 22-25, 1891.

species is of course rendered difficult by the as yet uneradicated error of considering pollen-tube and embryo-sac contents in the light of organs belonging to the sporophytic forms of the species. I have had occasion before, in these pages,³ to call attention to the wellnigh hopeless confusion of botanical terminology in this region of the science. When Goebel speaks of the fertilized macrospore of *Pilularia* being attached to the ground by its prothallial rhizoids⁴, or when Müller entitles a work "The Fertilization of Flowers," in which *fertilization* is not even mentioned, it serves to illustrate how deeply rooted is the fault of nomenclature which perpetuates the ancient errors of Camerarius, Linnæus, Sprengel and Erasmus Darwin.

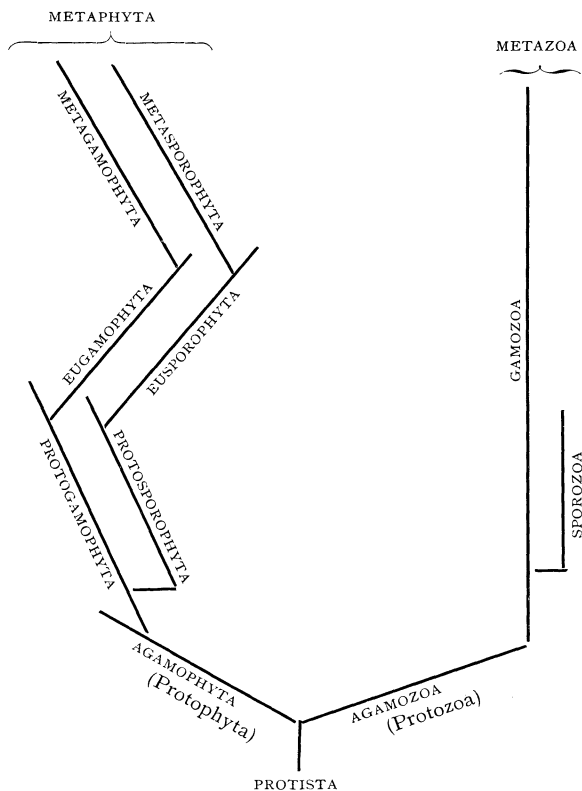
It is clear that there must still be much study before botanists can hope to define their species correctly, to say nothing of grouping them in an enlightened manner. The emancipated zoölogists of the day are accustomed, with an air not unfamiliar, to deprecate the attention bestowed upon classification and systematic work by the botanists. They do not, perhaps, discern that in a way the problems of the botanist are two-fold as complex as their own, just as the organisms with which the botanist has to do are doubly complicated. Up to this time so little material has been examined that there are very few species of Gamophyta accurately described. It is inconceivable that there should not exist differences between the male plants of *Salix* and *Populus*, for example, in some way related to the differences between the sporophytes. What these differences are is a task for future investigation. It may be many years before the *Genera Plantarum* or the *Histoire des Plantes* of the higher Gamophyta is written; but such a work is imperative before it can be pretended that we are in a position to fitly describe or classify the plant phylum in a final manner.

The evolution of sporophytic structures in the plant kingdom is so considerable that certain divisions should be noted in their development if they are to be set off against the far less important and less highly evolved group of the Sporozoa. Otherwise a wrong impression will be given in the comparison. With this in view it may be advisable to recognize in

³Bot. Gazette, xvi, 178, 1891.

⁴Goebel: Outlines of Classification and Special Morphology, Eng. tran., 243.

both the Sporophyta and the Gamophyta three fairly well-marked physiological divisions: first, the lowest Sporophyta are included in the gametophytic body and are therefore parasitic upon the sexual plant, e. g., *Ædogonium*, *Chara*, *Riccia*. Second, the higher forms are self-supporting and do not nurse the gametophytes, e. g., the higher mosses, the lower fernworts and club-mosses. Third, the highest forms act as host-plants for dependent, symbiotic gametophytes and



are so specialized, e. g., the seed-plants and the higher fernworts and club-mosses. These groups might be named respectively the Protosporophyta, Eusporophyta, and Metasporophyta, in order to facilitate reference without paraphrasing. Similarly, the lowest Gamophyta do not furnish nutriment for sporophytic structures of their own species, e. g., *Ulo-*

thrix, Fucus, Peronospora. The higher support dependent sporophytes, e. g., *Ædogonium*, *Marchantia*, *Sphagnum*. The highest are symbiotically parasitic upon sporophytic structures of their own species, e. g., the *Isoetineæ*, *Selaginellæ* and *Siphonogama*. These might be named respectively the *Protogamophyta*, *Eugamophyta*, and *Metagamophyta*. It is this last division that constitutes the principal part of the unexplored region. The accompanying diagram indicates the grouping of living things here suggested.

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Some fungi common to wild and cultivated plants.

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Reference is here made to the relation of the fungous parasites of wild plants, including weeds, to our crops whether of fruit, grains, or vegetables. This deleterious influence can best be brought out by taking up some of the worst fungous enemies to crops and showing the range of these parasites upon the surrounding wild plants.

Starting with the garden vegetables it is easy to find illustrations on every hand. Thus the lettuce mildew, *Bremia Lactuæ* Reg. is found up to date upon no less than forty-one species of plants belonging to the same family as lettuce and closely related to it. Many of these hosts for the mildew are common garden weeds and others inhabit the uncultivated ground.

The celery rust, *Cercospora Apii* Fr. now so destructive with truckers, is common to the carrot and parsnip also, and as the wild form of these abound without stint in many localities we need not wonder that the garden plants are partially destroyed by this pest.

There is a mildew of the spinach, *Peronospora effusa* Gr. that flourishes upon the pigweeds generally, there being no less than ten of these weeds that are thus infested and furnish a propagating place for the mildew of their patrician cousin grown on a salad plant.

The bean rust, *Uromyces appendiculatus* (P.) is one among a conspicuously destructive group of fungi that makes its home upon several species of wild beans.